Variations

Locate me on it: switch to Manual settings and reset time to 8th June 1968, 0:00 pm, in 3-hour steps. RedShift will take about 90 seconds—depending on the speed of your machine—to calculate Icarus' position back to this date. Center on and lock Earth; show planets, their labels and orbits, and show proper names for stars. This view shows Icarus' closest flyby to Earth.

Show me it: switch to Manual settings and reset time to 12th June 2015, in 1-day steps. RedShift will take about a minute to calculate Icarus' position on this date; the asteroid's next closest approach to Earth is 16th June 2015.

Toutatis

Another asteroid that periodically makes a close approach to Earth, most recently in 1992, when it was intensively observed using optical and radar instruments.

Locate me on it

At a distance of about 0.0425 AU, we see Toutatis' next close approach to the Earth in 1996.

Show me it

An orrery of the same encounter.

Variations

Locate me on it: set Zoom to 10.

Show me it: choose Recommended settings, then reset to Manual; change the Location panel settings to Longitude 270°, Latitude 89°, Height 1 AU; alter time steps to 1 hour; center and lock on Earth, with a Zoom of 2. You will see RedShift's prediction of the close encounter in much more detail.

Hale-Bopp

This "new" comet was discovered in 1995 and promises to be one of the great astronomical phenomena of 1997.

Locate me on it

At first the ride on the comet seems unspectacular, but as you rise above the ecliptic plane and approach the inner planets (magnified for effect), the strong inclination of the comet's orbit makes for a vertiginous approach to the Sun.

Show me it

The very strong inclination of Hale-Bopp's orbit to the ecliptic plane is clearly shown in this view of the Solar System.

Variations

Locate me on it: center and lock on Earth.

Show me it: switch to Manual settings; set your location to either Calgary or London, Earth; 22nd March 1997, 5:29 pm local time, time step 30 minutes; Horizon view. Under **File, Preferences...** set the sky color to Natural, and set your Center on panel to Azimuth 0°, Altitude 40°, and set a Zoom of 0.5. As day changes to night you will see Hale-Bopp stay above the horizon for several days.

Russel 1

This is an example of a comet whose orbit is changed by the gravitational influence of a large planet, in this case Jupiter in 1989.

Locate me on it

From a starting distance of about 0.226 AU, we see a view of the entire Jovian system from Russel 1.

Show me it

An equatorial view of Russel 1's orbit. After its close approach with Jupiter, it undergoes a significant shift in orbit.

Variations

Show me it: in the Object Filters Group dialog, set Show comets, with no labels. Then find Russel 1. On leaving the dialog box, click the *Orbit on* button in Russel 1's information window, then click the *Draw paths* button. Run time. You will now see two versions of Russel 1: the Space Flight special object, and the standard RedShift 2 object. They will obey the same orbits up to the encounter with Jupiter, but after the encounter the special object alone will undergo an orbital shift. This is because the standard object's journey is calculated under the formulae of the two-body problem, which is to say it only follows the motion dictated by the Sun.

Shoemaker-Levy 9

The collision of fragments of the Shoemaker-Levy comet with Jupiter in 1994 was one of the most spectacular astronomical events of the year. This special object setting uses the data for the last, W-fragment of the comet. When the impact finally occurs, however, RedShift's comet passes through Jupiter, whereas the real comet exploded in Jupiter's atmosphere with devastating effect. See the Photo gallery for pictures of this impact.

Locate me on it

A view approaching the planet before impact.

Show me it

A view from a fixed position above. As the comet gets closer to Jupiter, you can zoom in for a better view.

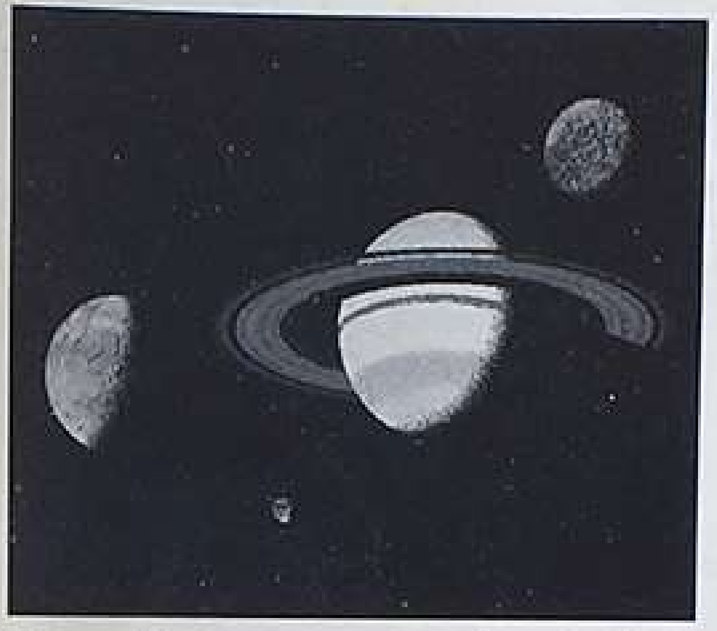
Variations

Locate me on it: choose Recommended settings, then reset to Manual, using a shorter time step.

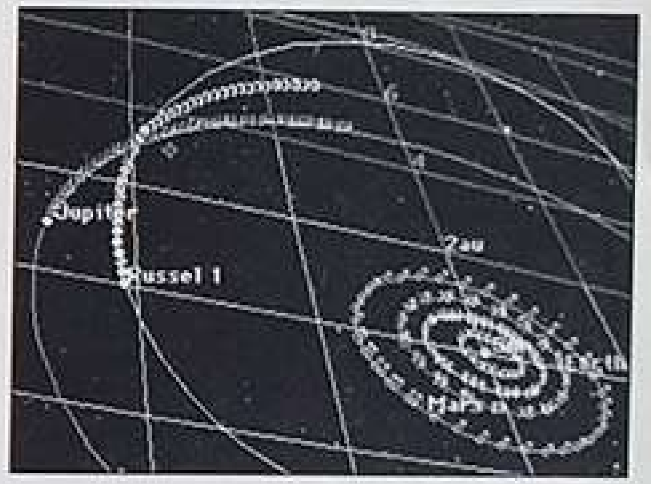
REDSHIFT 2—GUIDE TO SPACE FLIGHT

Please note that this leaflet updates the information about Space Flight in the main manual, mostly to be found on pages 23-24. If you are a new user, you will find it helpful to familiarize yourself with the manual before reading further; it is assumed here that you know how to use the control panels and filters to change settings, and understand RedShift's basic terms.

WHAT IS SPACE FLIGHT?



Space Flight is a new feature of RedShift 2 that allows you to take a ride on a number of exceptionally interesting space objects, including Earth satellites, spacecraft, space probes, comets and asteroids. It employs detailed coordinate data and higher-level calculus to give a realistic account of each object's journey through space, recreating the influence of perturbing forces—especially the gravitational effects of nearby planets. You can either look at the object as it travels, or from it as an observation point. As well as giving some spectacular preset views of planets, Space Flight adds new depth to the Photo gallery: you can, for example, take Voyager 2's journey past Saturn and cross refer to photos taken by the spacecraft at your present point and time in the journey.



HOW TO USE SPACE FLIGHT—general principles

To access Space Flight select Events, Space Flight...

The dialog box gives you a list of folders that contain settings for different objects. Double-click a folder to open it, then click a setting to select it. Some objects have more than one settings file.

The dialog opens with buttons preset; if they are altered, next time you open the dialog in your RedShift session your choice will be shown and applied to further settings.

Locate me on it is activated by default; this view uses the space flight object as your viewing platform. Or, you can choose **Show me it**, which gives a view of the object from a preset point in space.

The settings file for an object may include not only the date and time, and the step sizes in which time runs, but also the magnitudes of nearby planets and filters for stars and constellations, among other parameters. This combination is called the **Recommended settings & controls** for the object setting, and its effect is to give two of the most interesting views possible for the object (one view from **Locate me on it**, the other with **Show me it**). When you first open the Space Flight dialog box, Recommended settings are selected by default.

When RedShift has implemented the Recommended settings and redrawn the screen, start time running to enjoy the sequence. Within Recommended settings you can alter all settings except date, time and time steps.

In the notes on each object you will find suggestions for variations you can try, sometimes within Recommended settings, sometimes having switched to **Manual settings & controls**, which allow you to adjust date and time steps. When you choose Manual settings, RedShift establishes the location coordinates, time setting and calculus for the object, but nothing else is reset (most significantly, your present location is not reset, so you could for example choose to view Apollo 13 from a constricting present location: say, Pluto). This allows you to conduct your own experiments with time, and build up viewing settings to follow your own interests. However, you will get a warning that manual adjustment of date and time can result in very long calculations. *The shorter the time step, the easier it is for RedShift to perform the complex motion calculus required, and so the recommended time steps are optimized for interest and convenience. For example, if you ask RedShift to calculate the movement of Voyager 2 after its encounter with Neptune in 1000-year steps rather than 30-day steps, it may take half an hour to calculate each step, and will appear to have crashed!* Experiment with time steps by moving gradually outside the recommended parameters.

To end your session either select **Controls, Default Settings...** (to start afresh), or click **Stop space flight session** (if you want to preserve your view but change to a new date, switching off the special calculus).

Note 1: RedShift space flight calculus does not take account of the facts that spacecraft land, and comets vaporize on impact with a planet—so an object that crashes or lands will appear to pass through a planet's center.

Note 2: If the **Locate me on it** button is dimmed in the Space Flight dialog box, you will need to close one or more of the Follow planet, Position, Zoom or Location panels before you can use it.

Note 3: If you want to locate yourself on a special object without resetting time, do so using Choose Location or the Location panel.

Note 4: If you alter the settings panels, the **OK** light glows red to show that you must click it to confirm changes.

GUIDE TO SPACE FLIGHT OBJECTS

Mir

Mir is the best-known and longest-functioning space station, launched by the Soviet Union on 20th February 1986. Its name means "World" or "Peace" in Russian. It has been inhabited continuously since launch, its cosmonauts carrying out numerous research projects concerned with pure science and industrial materials.

Locate me on it

This shows a realistic view of the area of Earth that a cosmonaut can see from Mir; the date chosen is 7th July 1995. (Realistic view means a magnification of 1 for the object being observed). Note the exceptional speed with which Mir orbits Earth: the time steps are just one minute.

Show me it

The view is from Moscow, of Mir tracking through the night sky. The time step is 6 seconds. (Some users may need to reposition the Time and Location panels that initially hide Mir rising in the East.)

Variations

Locate me on it: in the planet filter, set the Sun's magnification factor to 5; center and lock the Sun; set time to 7th July 1995 at 07:31 UT; keep the time step on 1 minute. Running time forward, you will see sunset and sunrise as visible from Mir.

Show me it: switch to Manual settings, locate yourself on Mir and then open the Follow planet panel to see Mir in orbit; set the time step to one minute. Now you can see Mir's very fast orbit relative to Earth's rotation—it completes one orbit every 93 minutes.

ERS-1

Earth Resources is a satellite launched by the European Space Agency (ESA) on 17th July 1991. Its sensing equipment scans Earth at various wavelengths, including infra-red, enabling it to sense environmentally important phenomena—such as pollution—that are invisible to ordinary light. It has a near polar sun synchronous orbit at a height of about 780 km.

Locate me on it

A realistic view of the area under the satellite.

Show me it

Viewed from a distance of some 29,000 km in a leading position, it is clear that the orbital plane of the satellite keeps it synchronous with the sun: half its orbit is kept in darkness.

Variations

Locate me on it: switch on a medium grid setting in the Planet Filter dialog box, to see the equator, which you cross.

Show me it: switch off phases and observe the above position of the satellite to view its passage over the north pole. With phases switched on, change to the inward and then outward positions. These show that ERS-1's orbit, combined with Earth's rotation, gives it the optimal location to image every spot on the globe both in direct sunlight and at night. Then compare ERS-1's orbit with Mir: return to Leading position, then select Mir with Manual settings (you will retain your present location). Change the time step to 92.45 minutes and run time. You will see Mir moving very slowly to the left with respect to the Sun, crossing the day/night divide. Mir's orbit is not sun-synchronous.

Vega-1

This Soviet multimission spacecraft was one of a pair that followed broadly similar paths. It first flew to Venus and dropped a balloon probe; then, with the help of a gravity-assisted "slingshot," encountered Halley's comet.

Earth to Venus: Locate me on it

Just before the close approach to Venus.

Earth to Venus: Show me it

The interplanetary flight path.

Venus to Halley: Locate me on it

This reconstructs the view seen by Vega-1's TV camera during the Halley flyby. Unlock Halley and let time run for a few seconds; this will enable you to click Halley and switch on its orbit; then center it again and lock it. As time runs again, you will see changes in the comet's orbit, initially modest and then much more notable. After a few minutes of the closest flyby, the orbit becomes more stable.

Venus to Halley: Show me it

This shows the flight scheme of the Vega-1 mission. Halley appears only after a few steps; when it does, click it and again switch on its orbit.

Phobos-2

A Soviet interplanetary mission to explore Mars and its moon Phobos, launched on 12th July 1988, this was the last probe successfully to reach Mars. Its pictures of Phobos were taken from the closest distance yet achieved by any probe.

Phobos-2: Locate me on it

The final approach and flyby of Mars, which lasted just two days.

Phobos-2: Show me it

The interplanetary flight scheme.

Variations

Locate me on it: click Phobos as you approach, and click *Photo* in the Information window. Catalogue numbers 2001 & 2002 are those taken by the Russian probe; other photos from US missions are also to be found.

Show me it: switch to Manual settings, ensure the probe's label is switched on, and set time to 29th January 1989, 11:00 am, time step 1 minute; location Mars surface, Longitude 75°E, Latitude 0°, Center on Azimuth = 270°, altitude 60°; Horizon view, Zoom = 0.5; Planet filter: show icons, labels, but not orbits; Stars: show proper names; show coarse grids and show Zenith marker. This gives a view of Phobos-2 as from Mars; at first it will slowly descend towards the horizon; then suddenly ascend at a very rapid rate.

Ulysses

An ESA mission launched on 6th October 1990, Ulysses was designed to further research into the solar wind. Following a gravity-assisted "slingshot" from Jupiter, it traveled first to the solar south pole in 1994 and the north pole in 1995.

Earth to Jupiter: Locate me on it

The beginning of the flight to Jupiter. The Sun is about 1 AU away, and it has been slightly magnified, as have other planets.

Earth to Jupiter: Show me it

A beautiful and very interesting view of the probe's flight plan. It uses Jupiter's enormous gravity to kick it into the required Sun orbit—as it does so, the probe's instantaneous orbit undergoes a startling transformation—rather than depend on the expensive use of rocket fuel.

Jupiter-centered: Locate me on it

A view of the entire Jovian system.

Jupiter-centered: Show me it

Another view of the gravity-assisted "slingshot," this time in smaller steps.

Post Jupiter: Locate me on it

This Sun-centered setting takes you quickly through the whole orbit around the Sun's poles.

Post Jupiter: Show me it

A view of Ulysses showing the ecliptic plane and Solar System orbits. The angle to the ecliptic of Ulysses' orbit is about 81°.

Variations

Jupiter-centered, Locate me on it: select Recommended settings, then return to choose Manual settings and alter time to 7th February 1992 0:00 am, time step 10 minutes, and add a coarse grid for Jupiter. This gives you a more detailed flyby of Jupiter showing the relative move from northern to southern hemispheres. Or, using the Recommended settings, set Zoom to 1, giving a realistic view.

Post Jupiter, Locate me on it: use a greater magnification of the Sun and shorter time steps to get a better view of the Sun's poles.

Icarus

Icarus is one of a group of asteroids that are in orbits entailing close encounters with Earth. On 14th June 1968 Icarus had its most recent close pass to us, when it flew by at a distance of just 0.4 AU from Earth—about 60 million kilometers.

Locate me on it

This is a view of the Sun and planets from Icarus on 14th November 1996. Icarus' inclined orbit results in a view of the Solar System from both above and below the ecliptic plane.

Show me it

An orrery of Icarus' orbital motion.

Lageos-1

A geodynamical satellite, full name Laser Geodetic Survey Satellite, launched 4th May 1976. It is "passive," meaning it has no thrusters. An array of light reflectors allow its position to be measured with extreme accuracy: the satellite is bombed with laser light from ground-based tracking stations, which measure the photons reflected to Earth, calculating their journey's length to within 1 cm. Thanks to this precision, the satellite can be used to record very small-scale effects in Earth's crust dynamics.

Locate me on it

A realistic view of Earth with a tracking step of 5 minutes.

Show me it

Lageos-1's orbit relative to Earth, with a time step of 1 hour.

Variations

Locate me on it: using the Object Filters Group dialog, switch off Earth's atmosphere and phase, and switch on a medium grid and the Stars' proper names.

Show me it: change Earth's Planet setting to no atmosphere, no phase, medium grid. Use the Position panel to move to Longitude 135°E, Latitude 0°. Run time. You will see that Lageos-1 is moving from bottom right to top left relative to Earth's surface: a typical kind of orbital motion for a satellite whose inclination is more than 90° (Lageos-1 is inclined at around 110°). This view also shows the areas of Earth where Lageos-1's position can be measured; the tracking stations are widely spread.

Lageos-2

Launched 15th October 1992, this satellite is similar to Lageos-1, but with a more eccentric orbit, inclined at around 53°.

Variations

Show me it: switch to Manual settings. Set the Planet setting for Earth to no atmosphere, no phase, medium grid. Use the Position panel to move to Longitude 29°E, Latitude 0°, D.km 00030000; set time to 222.3-minute steps. Run time. Lageos-2's orbital plane slowly alters. This is because Earth is not an ideal spherical body with a uniformly distributed mass, but an oblate body with an imperfectly-centered gravitational field.

Etalon

A Soviet-launched passive geodynamical satellite equipped with light reflectors for laser observations. It was launched on 10th January 1989, into the same orbit as the satellites of the Global Navigation System (this is Russia's equivalent to the American Global Positioning System). "Etalon" is a Russian word for "standard."

Locate me on it

A realistic view of Earth from the satellite, seen in 20-minute steps. The Sun briefly tracks through the sky before Earth occults it.

Show me it

Etalon seen from the surface of the Moon. Earth is zoomed by a factor of 2.31.

Variations

Locate me on it: change Earth's Planet setting to no atmosphere, no phase, medium grid; show Stars' proper names. Switch on Constellations with boundaries and names but no patterns. By running time you will see an interesting view of the changing star map behind Earth.

Show me it: switch to Manual settings, and reset your location to Kansas City, your date to 1st January 1996, and your time to 6:00 am local time. Reset Zoom to 1 and choose Horizon view, then find Etalon and lock on it: you now have a view of a Space Navigation System object in the sky above a given place.

Interball

Interball is a Russian Earth satellite with a strongly apocentric orbit, launched on 3d August 1995 to carry out research on Earth's magnetosphere and other Sun-Earth interactions.

Locate me on it

Running time forward gives a dramatic, even vertiginous view of Interball's orbit as Earth approaches and falls behind.

Show me it

An illustration of an apocentric orbit. The Moon gradually moves into view.

Variations

Locate me on it: switch off Earth's phase and atmosphere, and switch on Stars' proper names.

Show me it: switching to Manual settings each time, you can compare the orbits of previous satellites.

Granat

Another Russian Earth satellite with an apocentric orbit, launched on 1st December 1989 as part of an international project in astrophysics, it is equipped with large telescopes to examine deep sky sources, including X-ray emitters. Its name means "pomegranate," and is also a Russian acronym referring to its various functions.

Locate me on it

In the center of the screen is X-ray source 3A921-630 (the purple object among the three visible). A few minutes after time starts running, Earth passes between Granat and the source, occulting it.

Show me it

The satellite's apocentric orbit is less pronounced than that of Interball; the Moon's orbit is given to illustrate distances from Earth.

Variations

Locate me on it: by centering and locking Earth (show Poles only), and switching on Constellation names and boundaries, you can see a striking view of Earth's motion against the star map.

Geostationary Satellite

This is a fictitious example of a typical geostationary Earth satellite; ie, one whose orbital period is equal to that of Earth. The result is that the region of Earth below the satellite stays approximately the same. Such satellites are very useful for many purposes, especially communications. Probably the best-known examples are television broadcast satellites that beam signals to a particular area of the world.

Locate me on it

At first it appears that the satellite is moving around Earth, constantly on the dark side. As the 30-minute steps progress, this illusion is dispelled: the area of the satellite's "footprint" (in this case, the Americas and part of the Pacific) experiences sunrise.

Show me it

The satellite as seen from Oklahoma City.

Variations

Show me it: return to Interball (Show me it), then switch to Manual settings and compare its orbit with that of the Geostationary satellite, and then ERS-1. Geostationary satellites orbit at a considerable distance from Earth.

Apollo 13

Scheduled to be the third manned spacecraft to land on the Moon, Apollo 13 was launched on 11th April 1970 and suffered an onboard explosion two days later, at 1:13 pm. Although its crew had to suffer extreme cold on the return journey to Earth, all three men survived.

Locate me on it

The view is from not very long after the spacecraft left Earth's atmosphere. As time proceeds in 10-minute steps, you will see Earth recede very quickly. At around 2:05 pm on the 14th April, the far side of the Moon begins to occlude the view, and as the spacecraft passes round the Moon, Earth comes into view again. Since the first part of the journey is straightforward interplanetary travel, you may prefer to record a movie and then use fast-forward controls to take you to the Moon and Earth encounters.

Show me it

This view shows Apollo 13's entire journey, seen from around 830,000 km above. The trajectory was designed so that the spacecraft would get a gravity-assisted "slingshot" as it swung round the Moon; if anything went wrong, instead of using its rockets to maneuver itself into a Moon orbit, it could simply continue the trajectory given it by the Moon's gravity. This was practical pessimism, since an explosion did occur as the spacecraft pulled in towards the Moon.

Variations

Locate me on it: switch to Manual settings; center and lock on the Moon, give the Sun a magnification factor of about 3, and set the time step to 1 hour. This enables you to fly to the Moon quite quickly; when the Moon is large reset the time step to 3 minutes, and observe the flyby in more detail. Another variation is to set Earth's magnification to 10, center and lock on it, and set time to 3:25 pm on 14th April 1970, proceeding in 30-second steps. You will see Earthrise over the Moon.

Show me it: switch to Manual settings; in the Position panel click *Moon* and set D.km to 00054160, longitude 0°, Latitude 84°E; set time to 14th April, 12:00 pm and a time step of 5 minutes. Running time forward, you will see the close flyby of Apollo 13.

Venera-7

Venera-7 was the first Soviet space probe successfully to land on Venus, on 15th December 1970. It returned 23 minutes of data before the planet's extreme conditions of pressure and heat disabled it. You can find the Venera-7 landing site on the Venus map.

Locate me on it

The approach to Venus, starting from 576,000 km.

Show me it

A scheme of Venera-7's entire journey. See how the probe's instantaneous orbit suddenly alters on 15th December as Venus' gravity draws it in.

Variations

Show me it: switch to Manual settings; set a location of Earth, center; Zoom at 0.6, Equatorial view. Switch off all planetary orbits, switch on a coarse sky grid, and click *Draw paths*. You see Venera-7's encounter with Venus as it was in Earth's sky.

Venera-13

Venera-13 was launched on 30th October 1981; during its flyby of Venus it dropped a probe that was the first to take color photographs of the surface, which proved to be orange.

Locate me on it

A view of Venus from Venera-13 on 28th February 1982. The planet is shown here without its dense atmosphere (RedShift's surface map was imaged by radio waves through this heavy layer of clouds).

Show me it

The interplanetary flight scheme. Again, the probe's instantaneous orbit is wrenched violently as it comes within the influence of Venus' gravity.

Variations

Locate me on it: as Venus approaches, stop time and switch on its atmosphere to compare the different views. In the Movie and Photo galleries there are more detailed radar-imaged maps of Venus' surface, as well as atmosphere images from Earth and Earth-orbiting telescopes.

Show me it: switch to Manual settings; set time to 3d January 1982 at 1:00 am in 5-minute steps; open the Follow planet panel and set to Above Venus at a distance of 00118558 km; running time forward gives you a detailed view of the Venera-13 flyby.

Voyager Missions

Voyagers 1 and 2 were twin space probes, launched by the United States in September and August 1977 to take advantage of a once-per-century favorable alignment of Jupiter, Saturn, Uranus and Neptune that would enable each Voyager to observe outer planets of the Solar System in one relatively short and gravity-assisted journey. Both missions were enormously successful, relaying back to Earth not only information about the background radiation in the Solar System, but more spectacularly a wealth of images of the planets and moons they encountered, drawn from both the visible and invisible parts of the spectrum. Many of these images are to be found in the Photo gallery—remember that you can click a planet or moon at any time and access photos through its Information window. For simplicity, only the more noteworthy settings are annotated; experiment with the others to see what you find!

Voyager 1 to Jupiter

Injection to Jupiter: Locate me on it

Voyager 1's view of Jupiter, starting from 10 days before the point of its closest approach (March 5th 1979).

Injection to Jupiter: Show me it

Voyager 1 was launched on 5th September 1977. Here we see its journey to Jupiter, which it reached two years later. "Injection" refers to the gravity-assisted "slingshot" that warped Voyager's orbit into a vast ellipse on its approach to Jupiter.

Jupiter-centered: Locate me on it

The view is locked on Io, Jupiter's moon, starting at a distance of 1,164,500 km from Jupiter and 759,000 km from Io. Photo 0327 in the Photo gallery was taken the same day. Click Io for a variety of images.

Jupiter-centered: Show me it

This orrery shows clearly how Voyager 1's trajectory took it very close to Io, Ganymede and Callisto. Io was found to be geologically extremely active; some scientists had already predicted that Jupiter's massive gravity would cause volcanic activity.

Variations

Jupiter-centered, Locate me on it: switch to Manual settings. Find, center and lock Callisto; switch off the moon's phases. Run time; you will see Ganymede pass close by. When you get closer to Callisto, change your Zoom factor to 5. Another variation is to return to Recommended settings, change to Ecliptic view, and in the Follow planet panel, change to 17,117,000 km above Jupiter, closing the panel. Check *Draw paths*. From a fixed point in space you can see the gravitational interaction of Voyager 1 with the Jovian system.

Voyager 1 to Saturn and beyond

Saturn-centered: Locate me on it

This view shows a realistic view of Saturn as seen by Voyager 1. Titan, Saturn's moon, is slightly magnified.

Saturn-centered: Show me it

This view shows the probe's close flyby of Titan, then its trajectory passing close beneath Saturn's south pole.

Post Saturn: Locate me on it

An equatorial view of the probe's escape from the Solar System. All planets are magnified.

Post Saturn: Show me it

Saturn's gravity swung Voyager 1 up and out of the ecliptic plane into interstellar space, whereas its twin's final flight mission was to drop below that plane, some nine years later. Because of the faint but thrilling possibility that either craft might eventually come into contact with an extra-terrestrial intelligence, both carried gold-coated phonograph records on which were encoded pictures of Earth, greetings in 54 languages, and a 90-minute selection of the world's music.

This view also illustrates the very strong inclination of Pluto's orbit.

Variations

Saturn-centered, Locate me on it: change to Ecliptic view, and in the Planet filter select a coarse grid and show Saturn's orbit. Repeat the flyby. Or, center and lock on Titan to see more clearly a very close encounter with the moon.

Saturn-centered, Show me it: change to Ecliptic view, and in the Planet filter show Saturn's orbit and Poles only; open the Follow planet panel, and set a distance of 7,600,000 km for the Inward button. As you run time you will see how Voyager 1 escaped from the ecliptic plane; until just after the encounter with Titan, its trajectory was largely stable, but it then swept dramatically upwards.

Voyager 2 to Jupiter

Injection to Jupiter: Show me it

The probe's flight scheme from Earth. It was launched on August 20th, 1977—before Voyager 1, but on a longer trajectory intended to give different results from its interaction with Jupiter's gravity.

Jupiter-centered: Locate me on it

A slower flyby of Jupiter than the Injection to Jupiter setting, this operates in 30-minute steps. Jupiter's satellites are slightly magnified. Jupiter's massive gravity meant that both Voyager probes had to stay millions of kilometers from the planet.

Jupiter-centered: Show me it

Voyager 2's flight path through the Jovian system.

Variations

Jupiter-centered, Locate me on it: choose Recommended settings, *OK*, then return and switch to Manual settings and find, center and lock on Ganymede. Set time to 8th July 1979, 0:00 am, with a Zoom of 5, then run time. To repeat the flyby for Europa, acquire the same settings for a date of 9th July at 3:30 pm.

Jupiter-centered, Show me it: slide to the maximum possible distance in the Follow planet panel to see the whole system of Jovian satellites, which are divided into the Galilean moons—Callisto, Ganymede, Europa and Io—and eight outer satellites. By switching to a longer time step you will see that the outermost four have a retrograde motion (which is as yet unexplained). Another variation is to choose Recommended settings, then for comparison choose the Voyager 1 setting for the same flyby using Manual settings. Voyager 1 passed much closer to Jupiter—within Io's orbit.

Voyager 2 to Saturn

Saturn-centered: Locate me on it

Beginning 4 years and 5 days after the probe's launch, this view starts at around 1,500,000 kilometers from the planet. The probe passed above Saturn's rings before passing beneath the planet, unlike its twin.

Variations

Saturn-centered, Locate me on it: find, center and lock on moons such as Titan and Tethys, experimenting with zoom factors of 5 or more.

Saturn-centered, Show me it: choose Ecliptic view, set your distance in the Follow planet panel to 11,000,000 kilometers, close the panel and click *Draw paths* to show Voyager 2's interaction with Saturn's gravity, which only significantly affects the probe when it comes within Tethys' orbit.

Voyager 2 to Uranus

To Uranus: Show me it

Uranus was also instrumental in forming Voyager 2's trajectory, again altering its orbit.

Uranus-centered: Locate me on it

Starting on the date of the probe's closest approach. Switch on Uranus' orbit; you will see that it is inclined (at nearly 98°), which means that the planet is to our way of thinking "on its side:" its poles are nearly aligned with the plane of the ecliptic.

Voyager confirmed and informed the observation, first made from Earth in 1977, that Uranus has rings.

Uranus-centered: Show me it

The Uranian system seen from above. RedShift 2's orrery does not include the ten minor satellites of Uranus revealed by Voyager 2.

Variations

Uranus-centered, Locate me on it: choose Recommended settings, then return to switch to Manual; find, center and lock Titania. Set Zoom to 5. This gives a realistic view of the magnification capabilities of Voyager 2's camera. Compare the images in the Photo gallery. Find, center and lock on Ariel to see both it and Miranda and Titania throughout Voyager's flyby.

Voyager 2 to Neptune and beyond

Neptune-centered: Locate me on it

On August 25th, 1989 Voyager 2—12 years into its journey—made its closest pass to any of the four planets it encountered, flying just 48,000 kilometers above Neptune's cloud-tops. By this point the signal returning from Voyager to Earth was roughly comparable to the wattage of a refrigerator light bulb, and NASA was using an arraying technique to unite data from two space telescopes in order to strengthen it.

Adding a coarse grid to the planet will give you a better spatial understanding of the flyby.

Neptune-centered: Show me it

This view shows the "slingshot" Voyager gained by its very close pass to Neptune.

Post Neptune: Show me it

Voyager 2's farewell to the Solar System. It passed beneath the plane of the ecliptic, whereas Voyager 1 passed above.

Variations

Neptune-centered, Locate me on it: choose Recommended settings, then return to switch to Manual; find, center and lock on Triton, choose a Zoom of 5, moon magnification of 1, and set the date to 25th August 1989 4:20 am. Running time shows an encounter with Triton that leaves it silhouetted against Neptune itself. Photo 2015 in the Gallery is a Voyager image of Triton of outstanding clarity.